One too many? Understanding the influence of risk factor quantity on perceptions of risk

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One Too Many? Understanding the Influence of Risk Factor Quantity on Perceptions of Risk

Running head: *Risk Perceptions and Risk Factor Quantity*

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ABSTRACT

Forming a subjective risk judgment in circumstances that feature multiple risk factors is a common, yet complex task. One would expect variations in the number of risk factors in a given situation to have an important influence on risk judgments, yet the exact nature of this influence remains empirically untested. We conducted three studies to address this issue. In Study 1, we found that, when individuals were confronted with a preset number of risk factors (zero, one, two *or* three) in the same scenario, their risk judgments were virtually identical for zero, one and two risk factors, yet markedly higher for three risk factors. By contrast, Study 2 showed that when confronted with variations in the number of risk factors (zero, one, two *and* three) for that same scenario, individual's risk judgments increased/decreased in relatively even increments concurrent with increases/decreases in the number of risk factors. Study 3 identified that pronounced increases in risk judgments, like those observed in Study 1, may occur when the numbers of factors is 'high' relative to the potential victim's vulnerability to those factors. Our results show that the number of risk factors in given circumstances can have an important influence on risk judgments and that this influence can differ based on the characteristics of the situation. We discuss how these findings provide a better understanding of subjective risk judgments and highlight the importance of those who seek to communicate risk information should be mindful of how data about multiple risk factors could be (mis)interpreted.

KEYWORDS: Judgment; multiple risk factors; risk communication; risk perception

1. INTRODUCTION

When forming a subjective judgment of the likelihood of an adverse outcome, it is essential to take account of the influence of each factor that might increase the likelihood of that outcome. For example, an individual who wishes to estimate how likely it is that he/she will develop heart disease could simply make a judgment based on whether or not he/she smokes. However, to arrive at a more accurate estimate, the individual should also consider his/her exposure to other risk factors for heart disease (e.g., poor diet, sedentary lifestyle, high alcohol consumption, etc.). Likewise, someone who is assessing the probability of a specific type of accident in their workplace should evaluate the potential influence of all risk factors (e.g., human error, equipment failure, etc.), rather than just one potential antecedent. Hence, when attempting to form accurate risk judgments, it is often important to consider how several risk factors might influence the likelihood of the adverse event; particularly, when the goal is to form subjective risk judgments that can reliably inform decisions regarding when best to take proportionate adaptive or precautionary actions.[(1)]

Forming a single subjective risk judgment that takes into account the influence of multiple risk factors is a complex task. For example, there is the challenge of making a reasonably accurate assessment of the risk attributable to each separate risk factor and, subsequently, assimilating these separate judgments to determine how the presence of each factor and/or each combination of factors might affect the overall risk.[(2)] Handling such complexities could prove to be cognitively demanding, particularly when time, mental resources, and/or relevant information are limited. Therefore, it seems reasonable to suggest that individuals may use simplifying cognitive strategies to help them to make these important subjective risk judgments. For instance, it is possible that individuals may utilize the number of risk factors in a given situation as a cue for inferring the overall likelihood of a specific adverse event.

In this paper, we present three studies that specifically aimed to assess how variations in the number of risk factors in a given context can influence risk judgments. Taken together, the three studies provide empirical evidence that shows (a) how individuals use the number of risk factors as a cue when judging the overall likelihood of an adverse outcome (b) the way in which individuals process information about the number of risk factors can lead to significant differences in their judgments of the overall risk and (c) 'perceived vulnerability to the number of risk factors' can have an important influence on risk judgments.

1.1. The Potential Effects of Risk Factor Quantity on Risk Judgments

Despite the powerful influence that the number of risk factors can have on the likelihood of adverse events and could have on related subjective risk judgments, there is a dearth of research that has specifically examined the extent to which individuals rely on the number of risk factors as an independent cue for inferring outcome likelihood. However, the closely related literature points towards two possible ways in which variations in the number of risk factors in a given situation might influence risk judgments. First, Support Theory and research on the 'numerosity heuristic' indicate that individuals might use the number of risk factors as a cue when forming risk judgments, with a greater number of risk factors being used to infer a greater probability.[3-6] Specifically, Support Theory suggests that probability judgments tend to increase when more details of a potential event are provided (e.g., higher probability judgments are provided for the chance of a terrorist attack occurring in Belgium, Germany, Holland and France, etc. than for the chance of a terrorist attack occurring anywhere in Europe). Support Theory argues that the provision of more details focuses the individual's attention on specific evidence and possibilities, and that this process of mentally 'unpacking' the description leads to the development of more vivid and salient mental representations of the event. Consequently, the individual believes that the event is more plausible and they increase their subjective probability judgment.[7; also see 8] Hence, in contexts

where the number of risk factors might vary, Support Theory indicates that the provision of more details about factors that can increase the probability of a particular adverse outcome could lead to increases in subjective risk estimates. Similarly, research shows that people often rely on a 'numerosity heuristic' when making risk judgments.[3,4,9] That is, individuals infer that the probability of a specific adverse event increases when there is a relative increase in the quantity of distinct elements of a particular 'risky' stimulus. For example, Pelham et al. (1994) developed a task in which participants had to choose between one of two routes across a minefield.[4] The first route featured five mines that each had a 0.2 probability of detonation and the second route featured ten mines that each had a 0.1 probability of detonation. The study revealed that, whilst the probability of avoiding a detonation was lower for the second route ($0.9^{10} > 0.8^{5}$), participants preferred the first route with less mines due to an inference that the lower numerosity of mines equated to less risk (note that this scenario demonstrates how risk judgments can vary when the quantity of the *same* stimulus is varied [i.e., five mines or ten mines] not when there is a variable quantity of *different* risk factors). Like Support Theory, evidence in support of the numerosity heuristic suggests that individuals might infer that greater number of risk factors positively correlate with a greater probability of the adverse outcome. Consequently, it is possible that individuals judge risk to increase proportionately with the number of risk factors (referred to here as The Incremental Increase Model).

On the other hand, some studies examining subjective risk judgments suggest that variations in the number of risk factors might have a different influence on risk judgments. Specifically, research has shown that individuals often form global impressions of how risky a situation appears and that this results in risk judgments that can fall into distinct categories of probabilistic magnitude, such as 'low' or 'high' risk.[2,10-12] For example, Lloyd, Hayes, Bell & Naylor (2001) found that patients who were awaiting a surgical procedure to reduce

their risk of stroke found it difficult to recall specific numerical risk figures given to them in an earlier consultation.[13] However, these patients were able to recall a categorical distinction between the lower and higher risk estimates that they had been given. As mentioned above, forming a subjective risk judgment for circumstances that feature multiple risk factors is a complex task. One method of simplifying such a cognitive challenge would be to utilize the number of risk factors as a cue for guiding globalized judgments of risk that distinguish markedly different risk magnitudes. In other words, individuals may form global impressions of how risky (e.g., low or high risk) the circumstances appear based on the number of risk factors present. Therefore, an individual's risk judgment might increase in a pronounced manner when the number of risk factors in a situation becomes relatively high. This may arise because his/her global impression of the risk associated with a relatively high number of risk factors is consistent with a distinctively greater level of perceived risk (referred to here as The Pronounced Increase Model). Consistent with this model, his/her risk judgment might also decrease in a pronounced manner when the number of risk factors in a situation becomes relatively low. This may occur because his/her global impression of the risk associated with a relatively low number of risk factors is consistent with a distinctively lower level of perceived risk.

1.2. The Present Research

The Incremental Increase Model is underpinned by a logical inference that as the number of risk factors increases the associated risk increases in an incremental fashion. The Pronounced Increase Model is not inconsistent with such logic. However, it does suggest the existence of a simplifying psychological mechanism that might serve to help individuals to identify when there may be a much greater/lesser need to consider instigating precautionary or preventive behaviors. Indeed, the existence of such a mechanism could provide a partial

explanation as to why individuals sometimes have attenuated or heightened risk perceptions in certain circumstances.[14]

We hypothesized that individuals may be more likely to make judgments that are consistent with the Pronounced Increase Model when they are required to form a single, global estimate of risk in a situation that features a set number of risk factors. In such circumstances, individuals may form a general impression of the overall risk without deliberatively assessing and assimilating individual risk magnitudes for each of the risk factors. Consequently, individuals may be more likely to arrive at a fairly rudimentary magnitude-category risk judgment (e.g., low or high risk). In such a case, a pronounced increase would be identified by a statistically significant increase in risk judgments when the number of risk factors increases by just one (e.g., from two to three risk factors).

By contrast, we postulated that individuals may be likely to make judgments that are more consistent with the Incremental Increases Model when the circumstances encourage them to make risk judgments that need to be revised as the number of risk factors in that situation increases or decreases. In such circumstances, individuals may revise their risk judgments upwards (downwards) in relatively equal increments as the number of risk factors increases (decreases). This could occur because the individuals may use their initial/prior risk judgment as a "*self-generated anchor*" [15, p. 391] against which they may logically deduce that the addition (subtraction) of other risk factors in the situation would increase (reduce) the level of overall risk. In such a case, incremental increases would be identified by the absence of statistically significant increases in risk judgments when the number of risk factors increases by just one and, therefore, by a more linear trend across judgments for all the risk factors.

We conducted two studies with the aim of examining the veracity of our propositions and a third study to identify what might lead individuals to make pronounced increases in risk

judgments based on variations in the number of risk factors. Analyses using GPower 3.1.9.2 identified that at 0.8 power the *F*-tests we employed for the main analyses in Studies 1, 2 and 3 could detect small-medium effect sizes (*f*) of 0.3, 0.15, 0.12, respectively, at the 0.05 significance level.[16]

2. STUDY 1

In this study we used a simplified scenario to assess whether individuals' risk judgments increased in a pronounced manner when the number of risk factors in the scenario varied (as a between-subjects factor) between zero, one, two or three factors.

2.1. Method

2.1.1. Participants

We recruited 126 undergraduate management students (60 women, 66 men) by verbal invitation during a lecture at a large UK university and gave them the opportunity to be entered into a prize draw to win one of three prizes worth £10, £25 or £100, respectively. The mean age of the participants was 19.1 years (*SD* = 1.72).

2.1.2. Procedure

Via an online survey, we presented each participant with a single written description of the same scenario: a group of one hundred running club members meeting for their weekly run in the local city park. In the scenario, the number of risk factors (zero, one, two or three) that could cause the runners to suffer an injury was varied as a between-subjects' factor. Participants were asked to provide a risk judgment, in a relative frequency format, regarding the number of running club members who would suffer an injury during the run. We opted to use a scenario about the risk of suffering an injury whilst exercising, as we felt that all participants would have some experience and/or vicarious knowledge of such an event.

The scenario was depicted as follows: "*Imagine a group of one hundred young adults who are all members of the same running club. For the past two years, all of these members have met once every week and run four miles around the flat concrete pathways of the local city park to get some moderate exercise.* [new paragraph] *One sunny morning the 100 members go for their usual weekly run in the city park."* The running conditions were depicted as being relatively safe for this group of runners (e.g., familiar location, flat pathways, good weather, etc.) to minimize the possibility that participants would perceive the 'background conditions' as a risk factor. Hence, participants reading this opening statement had been asked to imagine a scenario that featured a minimal, background risk of injury to the 100 runners (hereafter described as the 'zero risk factor' condition).

Those participants who were not assigned to the zero risk factor condition then read that the runners were exposed to either one, two or three additional factors that could increase the risk of an injury during the run. The risk factors that were described were either: the runners ran "*the first two miles along a different route on concrete pathways that go up and down steep hills"* ('steep hills' factor); the runners ran "*the second two miles across an uneven pathway"* ('uneven pathway' factor); and the runners ran "*an additional two miles (six miles in total) along the usual concrete pathways"* ('extra miles' factor). Participants were randomly allocated to either the zero (n = 32), one, (n = 33), two (n = 31) or three (n = 30) risk factor conditions.

In the one and two risk factor conditions, the risk factors featured in the scenario were randomly selected from the pool of three factors to negate the possibility that the mean risk estimates would be biased by specific single or combined factors. Furthermore, each of the three risk factors were described as operating at different stages in the run (first two miles, second two miles, and two extra miles) and, therefore, could not affect the runners simultaneously. This was done to ensure that this study would test the influence of the total

number of risk factors on the participants' risk judgments, rather than the influence of any perceived interactions between specific combinations of simultaneously occurring risk factors. In the three factor condition, all three factors were included. Having read details of the risk factors, participants were then asked to "*estimate how many of the one hundred members participating in this run you would expect to get a minor injury (e.g., a sprained ankle, muscle cramps, a cut/bruise from a fall, etc.) during this running session"*.

We considered the possibility that the participants might perceive one of the three individual risk factors (i.e., steep hills, uneven pathway, or extra miles) to be significantly more/less 'risky' that the other risk factors. If such a risk factor were depicted (cf. not depicted) in the 'one' or 'two' risk factor scenarios it could have led to disproportionate increases/decreases in the participants' risk judgments, and this would negate our ability to assess the extent to which the quantity, rather than type, of risk factor was affecting the risk judgments. To minimize this possibility, we conducted a pilot study in which we asked participants (N = 27) to provide risk judgments for the scenario depicting only one of the three single risk factors. We found no significant difference between the risk judgments (M = 9.85, SD = 8.18) for all three individual risk factors (steep hills, uneven paths, two extra miles: $F(2,24) = 1.15$, $p = 0.33$, $\eta^2_p = 0.09$).

2.1.3. Results

As shown in Figure 1, the participants' mean risk judgments for the zero (M = 11.16, SD = 13.92), one (M = 11.00, SD = 12.92) and two (M = 10.39, SD = 10.35) risk factor conditions were approximately equal. However, the participants' mean risk judgments for the three risk factor condition (M = 23.77, SD = 24.45) were more than twice that observed in each of the other conditions. We analyzed the judgment data using a one-way ANOVA and employed a planned contrast to test whether there was a significant difference between the risk judgments

of participants in the three risk factor condition and risk judgments in the other conditions.[1] The analysis revealed a main effect for the number of risk factors, $F(3, 122) = 4.87$, $p < .01$, $\eta^2_p = 0.11$, and the planned contrast revealed a significant difference between the risk judgments in the three risk factors condition and the judgments in the other conditions, $t(34) = 2.78$, $p < 0.01$, $d = 0.95$ (95% CI: 3.48-22.34).

[Insert Figure 1 about here]

2.1.4. Discussion

The lack of variation between the risk judgments provided by the participants in the zero, one, and two risk factor conditions suggested that, in contrast to the Incremental Increase Model, individual's risk judgments for situations that feature a variable number of risk factors do not necessarily increase as a function of the number of risk factors. However, consistent with the Pronounced Increase Model, we found that participants' risk judgments in the three risk factor condition were markedly higher than in all the other conditions. Hence, the results from Study 1 suggest that our participants formed globalized impressions of risk in which zero, one or two risk factor scenarios were perceived to represent a situation characterized by relatively equal and low levels of risk, whereas the three risk factor scenario was perceived to represent a situation characterized by a distinctively higher level of risk. This finding is important as it highlights that (a) it cannot be assumed that individuals increase their risk judgments in response to an awareness of more risk factors and (b) a reliance on globalized judgments of risk could lead individuals to negate some of the additional risk associated with certain factors (e.g., negating the potential difference between being exposed to zero and two risk factors).

While Study 1 provided support for the Pronounced Increase Model, we suggested earlier that individuals' risk judgments may be more consistent with the Incremental Increase

Model in circumstances where the individual is cognizant that the number of risk factors increases or decreases and, therefore, they could revise their judgments accordingly. To test this proposition we conducted Study 2.

3. STUDY 2

In this study, the same scenario was employed as in Study 1. However, on this occasion, the number of risk factors was varied as a within-subjects factor. This meant that each participant reviewed four scenarios in turn; each involving one of the four possible quantities of risk factors (i.e., zero, one, two, three). After reviewing each scenario they were asked to provide a risk judgment related to that scenario. This enabled us to assess the extent to which participants revised their judgments upwards or downwards based on explicit variations in the number of risk factors. Hence, in contrast to the risk judgments that were observed in Study 1, we expected to see, in line with the Incremental Increase Model, a positive correlation between the number of risk factors and subjective risk judgments.

3.1. Method

3.1.1. Participants

We recruited a separate sample of 83 undergraduate management students (48 women, 35 men) by verbal invitation during a research methods lecture at a different UK university. Students were asked to participate in order to improve their knowledge of empirical research. The mean age of the participants was 20.7 years (SD = 4.09).

3.1.2. Procedure

Via an online survey, each participant examined in turn four written scenarios that each described, identical to Study 1, a group of running club members meeting for their weekly run in the local city park. The number of risk factors depicted in each of the four

scenarios was varied as a within-subjects' factor so that each participant reviewed a zero, one, two and three risk factor scenario. The risk factors that appeared in each scenario were randomly selected from the same pool of three risk factors used in Study 1: 'steep hills', 'uneven pathway', and the 'extra miles'. Having read a given scenario, participants were asked to provide a risk judgment, in a relative frequency format, regarding the number of running club members who would suffer an injury during the run. As a between-subjects factor, the presentation order of the four scenarios was varied in one of three ways: (i) randomly (ii) incrementally increasing the number of risk factors from zero to three and (iii) incrementally decreasing the number of risk factors from three to zero. The presentation order was not varied in order to test a specific hypothesis, but simply to negate the possibility that the order might have influenced the participants' risk judgments.

3.1.3. Results

As shown in Figure 2, the participant's mean risk judgments increased incrementally across the zero (M = 8.05, SD = 15.11), one (M = 13.92, SD = 18.10), two (M = 16.52, SD = 18.94) and three (M = 21.08, SD = 20.71) risk factor scenarios. A 4 (number of risk factors: zero, one, two, three) x 3 (Order: random, inclining, declining) ANOVA identified a main effect for the number of risk factors, $F(2, 240) = 22.41$, $p < .0001$, $\eta^2_p = 0.22$, but no significant effect for Order, $F(2, 80) = 0.14$, $p = 0.87$, $\eta^2_p = 0.003$. A trend analysis also revealed a significant linear trend for number of risk factors, $F(1, 80) = 31.75$, $p < .0001$, $\eta^2_p = 0.28$, confirming that as the number of risk factors increased (decreased), the participants made higher (lower) risk judgments. No other significant main effects or interactions were found, Fs(3, 137) < 0.23, ps > .89, η^2_ps < 0.007.

[Insert Figure 2 about here]

3.1.4. Discussion

Consistent with the Incremental Increase Model, the participants in Study 2 revised their risk judgments upwards (downwards) in relatively even increments as the number of risk factors increased (decreased). This finding suggested that the participants had probably engaged in cognitive assessments that involved deliberatively assessing (a) the extent to which the addition (subtraction) of risk factors would affect the overall risk and (b) the coherence of each risk judgment relative to their prior risk judgments. By contrast, the participants in Study 1 had only needed to make a single risk judgment without cognitively assessing whether this judgment was logically consistent with any previous judgments. Without having a prior risk judgment(s) to act as an 'anchor', it appears that the participants in Study 1 had relied more on the number of risk factors as a cue to formulating a global impression of the overall risk and had arrived at more categorically distinct assessments.

4. STUDY 3

We recognized that Studies 1 and 2 did not provide a clear explanation as to why the risk judgments produced by the participants in Study 1 increased markedly when the number of risk factors increased from two to three. Clearly, it is important to understand why individuals may perceive the overall risk in a situation as markedly 'higher'/'lower' as such insights could help to better understand why and when individuals might be more likely to identify the need for risk management actions in a context that features differing number of risk factors.

A potential explanation for the marked increase in risk judgments observed in Study 1 could be that individuals generally perceive the overall risk posed by two or less risk factors as relatively small and equi-probable, but the risk posed by three or more risk factors as substantially greater. One clear rationale for not accepting this explanation is that several studies already show that most individuals judge the risk of suffering from a serious health

problem (e.g., heart attack, cancer) to be significantly greater for individuals who expose themselves to a single risk factor, such as smoking or regularly drinking large quantities of alcohol, than for individuals who do not.[e.g., 17,18] Hence, we hypothesized that an alternative and more plausible explanation would be that, when forming a global impression of risk, individuals might make their assessment relative to the perceived vulnerability of the potential victims to the given number of risk factors. That is, judgments may increase (decrease) in a marked manner when the number of risk factors increase (decrease) to a level which is perceived to be 'high' (low) relative to the potential victim's vulnerability to those factors. We arrived at this hypothesis because research shows that risk judgments often increase when the potential victims are perceived to be particularly vulnerable to specific risk factors.[19,20] Therefore, when an individual judges the risk attributable to multiple risk factors, his/her judgment may be influenced by the extent to which the potential victims are perceived as vulnerable to the number of risk factors in that context. Hence, for the scenario that we employed in Study 1, the risk judgments may have increased significantly for three risk factors because the participants believed that this accumulation of risk factors would become substantially more difficult for the runners to mitigate without suffering an injury. To examine whether marked increases in risk judgments, such as those observed in Study 1, could be a function of both the number of risk factors and the perceived vulnerability of potential victims to those factors, we conducted a third study.

For this study we developed a more complex scenario. The scenario enabled us to effectively manipulate vulnerability so that we could assess our prediction that risk judgments would only increase in a pronounced manner when (a) the number of risk factors was low and vulnerability to the risk factors was relatively high and (b) the number of risk factors was high and vulnerability to those risk factors was relatively low.

4.1. Method

4.1.1. Participants

We used Amazon.com's Mechanical Turk to recruit a sample of 378 US participants and paid them $1 each.[21,22] To identify inattentive participants, we employed an 'instructional manipulation check' (IMC).[23] Participants that failed the IMC were excluded from the analysis, leaving a final sample of 346 participants (146 women, 200 men). This failure-rate was lower than observed in previous tests of IMCs.[23] The mean age was 33.14 (*SD* = 11.64).

4.1.2. Procedure

Each participant reviewed a single written scenario that asked them to imagine a group of 100 different men who had no history of serious health problems. As a between-subjects factor, the 100 men were described as being either 25 years old or 65 years old (*vulnerability* factor).[1] In the scenario, the number of 'heart attack' risk factors (zero, one, two, three or four: *number of risk factors*) that the men had been exposed to throughout their adult life was also varied as a between-subjects factor. Participants were asked to provide, in a relative frequency format, a risk judgment regarding the number of men aged 25 (65) who would suffer a heart attack before reaching the age of 40 (80). Participants were randomly allocated to either the 25/65 years old condition (n = 166/180) and then further randomly allocated to either the zero (n = 33/37), one, (n = 36/36), two (n = 33/32), three (n = 35/36) or four (n = 29/39) risk factor conditions.

The scenario started: "*Imagine a group of 100 different men who are all 25 (65) years old and have no history of serious health problems. Throughout their adult life, all of the men have: …*" Participants in the zero risk factor condition then read that the men had (i) "*never consumed alcohol*" (ii) "*never smoked"* (iii) "*never been overweight"* and had (iv) "*always taken part in physical activities (such as sports, structured exercise routines, or other*

activities of a similar intensity and duration) at least once each week". Participants not in the zero risk factor condition read that the men had been exposed to either one, two, three or four risk factors that were described as: "*Always consumed an average of 4-5 units of alcohol (equivalent to two pints / 1.1 liters of beer) per day*" ('alcohol' factor); "*Always smoked 3-4 cigarettes per day*" ('smoking' factor); "*Always had a Body Mass Index (BMI) between 28 and 30, which means that they are approximately 50 pounds over their recommended weight range*" ('overweight' factor); and "*Not taken part in any physical activities (such as sports, structured exercise routines, or other activities of a similar intensity and duration)*" ('sedentary' factor). In the one, two and three risk factors scenarios, the text also stated to which of the four risk factors the men had not been exposed. The risk factors featured in the one, two and three risk factor scenarios were randomly selected from the pool of four factors. In the four factor condition, all four factors from the pool were included. Having read about the risk factors, participants then read "*Assuming that they do not change any of these lifestyle habits, how many of these 100 men do you think will suffer a heart attack before they are 40 (80) years old?*"

The use of this scenario enabled us to address two limitations of the scenario employed in Studies 1 and 2. First, the '100 runners' scenario represented a simplified situation (e.g., the runners were exposed to each of the individual risk factors sequentially rather than simultaneously and each risk factor did not present risks that accumulated over long time periods). Consequently, it was not clear whether the pronounced increase in risk judgments that were observed in Study 1 would be evident in circumstances that more closely mimicked the complex circumstances encountered in daily life (e.g., simultaneous exposure to risk factors; exposure to factors that present cumulative risks). Second, although the participant's risk judgments in Study 1 did not vary between the zero, one and two risk factor conditions, we believed that it would be highly unlikely that this lack of variation in

subjective risk judgments would be evident in all situations; as highlighted above, research evidence shows that subjective risk judgments can increase/decrease depending on the presence/absence of certain risk factors (e.g., subjective judgments concerning the risk of developing lung cancer for smokers [one factor] are typically higher than subjective judgments for non-smokers [zero factor]). This evidence led us to believe that the 'punctuated equilibrium' (i.e., a plateau in data points followed by a sudden increase) observed in Study 1 may not necessarily be as pronounced in all contexts. In other words, the '100 runners scenario' did not enable us to determine the extent to which the number of risk factors might still affect risk judgments in circumstances where each risk factor would be likely to increase subjective risk judgments beyond the level subjectively attributed to a 'zero risk factor' scenario. The new scenario was also developed to address this issue.

Based on our findings in Study 1, we predicted that a pronounced/significant increase in risk judgments would be evident in both the '25' and '65' year olds' conditions. However, consistent with the greater vulnerability of older people to cardiovascular incidents, we anticipated that the pronounced increase in risk judgments would be evident for a lower number of risk factors in the '65 (cf. 25) year olds' condition. Furthermore, consistent with the evidence highlighted above [(e.g., 17,18)], we also anticipated that our participants would perceive the risk of each individual risk factor to be greater than that subjectively attributed to the 'zero risk factor' scenario and, therefore, that these increases in perceived risk would be reflected in higher risk judgments for each additional risk factor in the scenario. Hence, in addition to observing a single pronounced increase in risk judgments in each of the two age conditions, we also anticipated that we might observe some modest incremental increases in the risk judgments as the number of risk factors increased.

As in Study 1, we considered the possibility that the participants might perceive one of the four risk factors to be significantly more/less risky than the other factors. Hence, we

initially conducted a pilot study in which we asked participants (N = 25) to provide risk judgments for the scenario depicting only one of each of the four single risk factors. We found no significant difference between the mean risk judgments for all four individual risk factors (alcohol, smoking, overweight, sedentary), $F(3, 24) = 0.008$, $p = 0.999$, $\eta^2_p = 0.001$.

4.1.3. Results

As shown in Figure 3, the risk judgments in both the '25 years old' condition (M = 19.65, SD = 23.07) and '65 years old' condition (M = 39.27, SD = 25.58) increased as the number of risk factors increased. A 2 (Vulnerability: 25 years, 65 years) x 5 (number of risk factors: zero, one, two, three, four) ANOVA revealed a significant main effect for Vulnerability, $F(1, 336) = 67.01$, $p < .0001$, $\eta^2_p = 0.17$, and for the number of risk factors, $F(4, 336) = 25.60$, $p < .0001$, $\eta^2_p = 0.23$. A trend analysis revealed a significant linear trend for number of risk factors, $F(1, 80) = 31.75$, $p < .0001$, $\eta^2_p = 0.28$, confirming that as the number of risk factors increased (decreased), the participants made higher (lower) risk judgments. There was no significant interaction between Vulnerability and the number of risk factors, $F(4, 336) = 0.74$, $p = 0.56$, $\eta^2_p = 0.01$. Hence, the analysis revealed that the participants tended to provide relatively higher risk estimates as the number of risk factors increased and that the participants consistently perceived a greater vulnerability to the risk factors amongst the 65 year old men (cf. 25 year old men).

[Insert Figure 3 about here]

Next, we performed an analysis using only the data from the '25 years old' condition to test whether a marked increase existed in the mean risk judgments across the zero (M = 5.86, SD = 15.84), one (M = 16.25, SD = 23.17), two (M = 16.73, SD = 14.40), three (M = 22.97, SD = 20.87), and four (M = 38.86, SD = 27.68) risk factor groupings. We ran a one-way ANOVA and employed Tukey's HSD post hoc test to compare pairwise differences

between risk judgments in each number of risk factors group and in the next sequential number of risk factors group (e.g., between the zero and one risk factor groups, between the one and two risk factor groups, etc.). We employed Tukey's HSD test due to its power and its capacity to control the overall Type I error rate.[24] The analysis revealed a main effect for the number of risk factors, $F(4, 161) = 10.43$, $p < .0001$, $\eta^2 = 0.21$, and the post hoc tests (see Table 1) found no significant (ps > 0.20) difference between the risk judgments in the zero and one factors groups, the one and two factors group, and the two and three factors groups. However, a significant ($p < 0.05$) difference was observed between the judgments in the three ($M = 22.97$) and four ($M = 38.86$) risk factor groups (95% CI: 1.47-30.31). We performed this same analysis using only the data from the zero ($M = 17.81$, $SD = 17.81$), one ($M = 35.14$, $SD = 20.50$), two ($M = 40.38$, $SD = 21.48$), three ($M = 44.89$, $SD = 24.08$), and four ($M = 57.36$, $SD = 25.56$) risk factor groupings in the '65 years old' condition. This revealed a main effect for the number of risk factors, $F(4, 175) = 16.16$, $p < .0001$, $\eta^2 = 0.27$, and the post hoc tests identified a significant ($p < 0.01$) difference between the risk judgments in the zero (M = 17.81) and one (M = 35.14) factors groups (95% CI: 3.06-31.59). However, no significant (ps > 0.10) differences were found between the risk judgments in the one and two factors group, the two and three factors groups, and the three and the four risk factor groups.

[Insert Table 1 about here]

4.1.4. Discussion

As anticipated, the results of this study show that, as the number of risk factors increased, there were modest incremental increases in risk judgments across both vulnerability conditions. However, our analyses also revealed that one marked increase in risk judgments was evident in both the 25 and 65 year olds conditions and that these marked increases were associated with fewer/more risk factors when the potential victims were

more/less vulnerable to the adverse outcome. Hence, while the pattern of risk judgments observed in this study demonstrated consistencies with both the Incremental Increase and Pronounced Increase Models, the findings are also consistent with our earlier explanation for the findings from Study 1. That is, both Studies 1 and 3 indicate that individuals' risk judgments may increase markedly (i.e., by a *relatively* larger magnitude) when the number of risk factors increases by just one factor and, more specifically, that these marked increases appear to be influenced by the potential victim's vulnerability to those factors. However, some caution must be exercised in drawing a firm conclusion that the marked increases are *directly* attributable to the potential victim's vulnerability. This is because the moderating influence of vulnerability can only be inferred from the existence/absence of significant difference in risk judgments between the risk factor groups in the 25 year old condition relative to the existence/absence of a significant difference in the 65 year old condition.

5. GENERAL DISCUSSION

Prior to the above set of studies, there had been a dearth of research concerning the extent to which the number of risk factors in a given context might be utilized by individuals as an independent indicator of risk magnitude. Taken together, the results suggest that, when forming a single isolated risk judgment for situations that feature any number of risk factors, individuals may, to some extent, rely on global impressions of the overall risk. Even when the factors are each regarded as posing a similar magnitude of risk, these global impressions are not necessarily characterized by even incremental increases in judged risk for each additional risk factor. Rather, globalized judgments may be characterized by a pronounced increase that occurs in response to increases in the number of risk factors that are perceived to be 'high' relative to the potential victim's capacity to tolerate those factors. Moreover, our results indicate that this 'one too many' effect may be sufficiently robust to be evident in situations where the risk factors present a fairly immediate threat to the potential victims (Study 1) and

in situations where the risk is cumulative and the adverse outcome is more temporally distant (Study 3). By contrast, the results of Study 2 indicate that when individuals are required to form risk judgments for each variation of the number of risk factors in a given situation, they may rely less on a global impression of overall risk and, instead, employ a 'logical' inference that risk increases/decreases in response to relative increases/decreases in the number of risk factors.

It is possible that our findings are consistent with the explanations of how people process and respond to messages as described by Petty and Cacioppo's Elaboration Likelihood Model.[25] Specifically, the Elaboration Likelihood Model suggests that individuals typically process persuasive arguments via one of two routes, known as the central route and the peripheral route. When following the central route, the individual engages in a careful and deliberative assessment of the information presented. When following the peripheral route, the individual makes simple affective or intuitive inferences that negate the need for complex cognitive processing.[26,27] It is possible that, when our participants formed their judgments in Studies 1 and 3, they avoided the cognitive burden of using the central route to assess and assimilate the influence of several individual risk factors. Consequently, they may have relied more on the peripheral route to form global impressions of risk in a relatively facile manner. The limited amount of detailed analysis in these judgments may have led the participants to form less precise estimates that are more attuned to distinguishing between lower and higher levels of perceived risk. By contrast, when participants in Study 2 were presented with variations in the number of risk factors, they would have been conscious of the need to ensure that their judgments were logically coherent (e.g., it would have made little sense for a participant to judge the risk of injury as 5 in 100 for the three risk factor scenario if he/she had already judged the risk of injury as 30 in 100 for the one risk factor scenario). Making these more coherent judgments would have involved

deliberatively comparing and revising risk estimates relative to any prior estimates. Consequently, they would most probably have been undertaken using the central route. The notion that our results are consistent with the Elaboration Likelihood Model is further supported by related empirical research by Petty and Cacioppo. In particular, this has shown that, when peripheral processing is engaged, the number of arguments in a message acts as an important cue that can substantially influence perceptions and attitudes. However, when central processing is engaged, each argument is more carefully evaluated and scrutinized and, therefore, has less influence on perceptions and attitudes.[28]

Our findings have important implications for risk communications, particularly when the difference between the results obtained in Studies 1 and 2 are considered. Study 2 suggests that, when individuals are conscious of a change in the number of risk factors in a given situation, they make rely more on central processing and alter their risk judgments relative to any prior risk judgments. Conversely, Study 1 suggests that, when individuals are spontaneously confronted with a situation that contains zero, one or more risk factors, they may rely more on peripheral processing and identify pronounced differences in the level of risk based on the number of risk factors present. This could lead to imprecise risk judgments (i.e., an attenuation or exaggeration of risk) that, subsequently, may act as a poor guide to the need for risk management actions. Hence, risk-related messages that simply confront individuals with a list of risk factors associated with a single potential outcome could, unintentionally, cause the recipient to judge the overall risk as being markedly lower or higher than the communicator intended, depending on the number of risk factors presented and perceived vulnerability. This has the potential for the individual to adopt a disproportionate behavioral response. An obvious remedy to this issue would be to develop communication techniques that motivate the recipient to employ central processing cognitions to make separate risk judgments for each factor before he/she arrives at a holistic

risk judgment. Importantly, in such cases, the risk communicator would need to make an assessment as to whether this latter approach is preferable in light of the specific objective that the message aims to achieve (e.g., behavioral change) and/or is ethically obliged to fulfill (e.g., to educate).

One further point to consider is that the aim of our research was to develop empirical insights into the effect that variation in the number of risk factors can have upon risk judgments, rather than to assess whether our participant's subjective risk judgments were consistent with some form of normative standard. For example, it was not our intention to determine whether the judgment pattern observed in Study 1 was more consistent with the 'objective' risk than the judgment pattern observed in Study 2 (in any case, there is an absence of empirical data concerning how the three specific risk factors [steep hills, uneven pathway, extra miles] would affect the likelihood of injury in the same context). Nonetheless, in relation to Study 3, it is interesting to note that epidemiological evidence shows that most heart disease risk factors interact synergistically. That is, the risk attributable to a given combination of heart disease risk factors typically exceeds the sum of the risk attributable to those constituent factors when operating alone.[29,30] Whilst the participants in Study 3 did provide higher/lower risk judgments relative to higher/lower risk factor quantities, these increased/attenuated judgments were relatively modest and did not reflect the synergistic relationships highlighted by the epidemiological evidence. This finding is consistent with other studies, which have found that people often underestimate the risk attributable to factor combinations that, according to empirical evidence, present synergistic risks.[31,32] Hence, a further important observation can be made from the results of Study 3 concerning an individual making risk judgments for situations that feature multiple risk factors. Specifically, we can infer that individual's judgments may be more likely to increase significantly when

the number of risk factors is high relative to the potential victim's vulnerability, rather than when those risk factors are ones that are known to interact synergistically.

5.1. Limitations and Future Directions

While the present research provides important insights into the influence of the number of risk factors on subjective risk judgments, it also illuminates other avenues for future research. In particular, we held the frequency of exposure to specific risk factors constant (i.e., smoked X cigarettes per day, consumed an average of Y units of alcohol per day, etc.) in order to control for the potential influence of this variable. Future studies could explore the extent to which variability in frequency of exposure might influence risk judgments for multiple risk factors. In addition, researchers could examine the extent to which the pronounced increase in risk judgments that we have observed under some circumstances are also evident in other domains (financial markets, environmental risk management, policy making, etc.) and the extent to which such judgments influence behavioral decisions. Furthermore, studies could aim to identify what contextual factors (e.g., age, socioeconomic status, history of suffering similar events, access to preventative measures, geographic location, etc.) might influence the extent to which potential victims are perceived as vulnerable to certain numbers of risk factors. Researchers could assess how these contextual factors influence the exact point at which pronounced increases in risk judgments occur as the number of risk factors changes. Moreover, future studies might also aim to assess how risk judgments are influenced by far greater numbers of risk factors (e.g., ten or more) with a view to identifying whether multiple pronounced increases, ceiling effects or, even, decreases in risk judgments are observed. Finally, future studies that use much larger sample sizes may find that it becomes harder to distinguish between incremental and pronounced increases because both types of increase may be statistically significant. To counter this issue, we suggest that researchers could set a *p*-value for identifying pronounced

increases (e.g., $p = 0.01$) that is relatively lower than the p-value set for identifying incremental increases (e.g., $p = 0.05$). In these circumstances, any increases that are statistically significant at the higher p level, but which do not meet the criteria set for a statistically significant pronounced increase, could then be classified as incremental increases only. Similarly, researchers could explore the merits of using predetermined effect sizes, such as low vs. medium effect sizes as defined by Cohen[16], to distinguish between incremental and pronounced increases, respectively, in studies that use larger sample sizes.

6. CONCLUSION

Our studies provide important new insights into subjective risk judgments. First, we have identified that it cannot be assumed that there will be a positive relationship between the number of risk factors and the magnitude of subjective risk judgments. Second, the evidence suggests that the absence of this positive relationship may result from a reliance on globalized risk judgments that are not based on a deliberative evaluation and assimilation of the risk magnitudes attributable to each risk factor. Third, our studies show that these globalized judgments can be characterized by pronounced increases in perceived risk that are formed with consideration of the potential victim's vulnerability to that risk. Moreover, we suggest that the existence of these pronounced increases in perceived risk may offer a partial explanation as to why individuals are sometimes indifferent or dismissive of some risk issues, yet concerned or alarmed by others. That is, when the number of risk factors elicits a pronounced increase in perceived risk, this may trigger a more precautionary state of mind, yet prior to the pronounced increase the individual may remain confident that the risk is negligible or easily mitigated.

Many risk-related circumstances are characterized by the presence of more than one risk factor and any subjective risk assessment for those circumstances should incorporate the

influence of multiple factors. In such circumstances, it may often be the case that individuals are required to make intuitive risk assessments within a restricted time frame, using little or no data, and having a limited cognitive capacity (or even motivation) to fully tackle the task complexity. One means of circumnavigating this task complexity is to rely on globalized impressions of the overall risk. Our studies suggest that, on one hand, such an approach may provide a sophisticated cognitive shortcut for identifying when precautionary action may be needed in response to a precarious combination of multiple risk factors and vulnerability. On the other hand, reliance on this approach could lead to over- or under-estimations of overall risk and, therefore, may not serve as an appropriate guide to related behavioral decisions. Hence, the results of our studies point towards a need for those who assess and communicate risk to carefully consider how information about multiple risk factors might be (mis)interpreted, with due consideration being given to the worst outcomes that could occur. Helping individuals to arrive at more balanced assessments of overall risk could be an important part of facilitating a journey towards behavioral responses that are proportionate to the vast array of hazardous situations that are characterized by multiple risk factors.

FOOTNOTES

1. Although it can be argued that age is itself a risk factor, we elected to manipulate age as a means of varying vulnerability. Specifically, because age is not modifiable, we used it in our study as a form of 'background risk' that could be varied in order to influence the degree of vulnerability to the other four modifiable risk factors.

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TABLES

Table 1. Study 3: Results of Tukey's HSD post hoc tests assessing the differences between the risk judgments for each pairwise 'number of risk factor' conditions. Test results are shown for both vulnerability conditions.

		25 year olds condition			*65 year olds condition*		
Number of risk factors (*i*)	Number of risk factors (*j*)	Difference between risk judgment means (*i* – *j*)	Standard Error	*p*	Difference between risk judgment means (*i* – *j*)	Standard Error	*p*
Zero	One	-10.39	5.02	0.24	-17.33	5.18	**0.01**
	Two	-10.87	5.12	0.22	-22.56	5.34	0.00
	Three	-17.12	5.10	0.01	-27.08	5.18	0.00
	Four	-33.01	5.30	0.00	-39.60	5.07	0.00
One	Two	-0.48	5.02	1.00	-5.24	5.37	0.87
	Three	-6.72	4.94	0.65	-9.75	5.21	0.34
	Four	-22.14	5.20	0.00	-22.22	5.11	0.00
Two	Three	-6.24	5.05	0.73	-4.51	5.37	0.92
	Four	-22.16	5.30	0.00	-16.98	5.23	0.13
Three	Four	-15.89	5.23	**0.02**	-12.47	5.11	0.11

Figures highlighted in bold indicate where the difference between the mean risk judgment for a specific scenario (e.g., the zero risk factor scenario) and the mean risk judgment for a scenario featuring exactly one more risk factor (e.g., the one risk factor scenario) was significantly greater.

FIGURES

Figure 1. Study 1: Participants' (mean) judgments of the number of 100 runners who would suffer an injury. Judgments are shown for each of the four risk factor conditions.

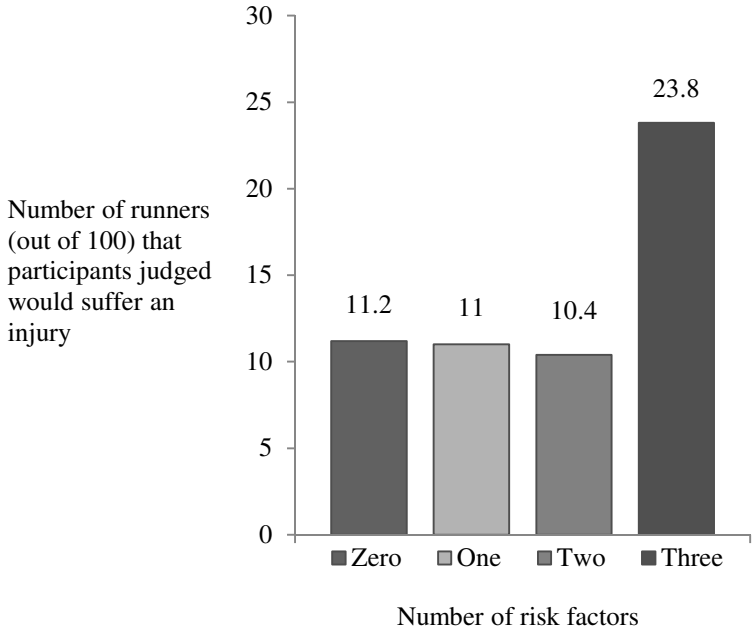

Figure 2. Study 2: Participants' (mean) judgments of the number of 100 runners who would suffer an injury. Judgments are shown for each of the four risk factor conditions.

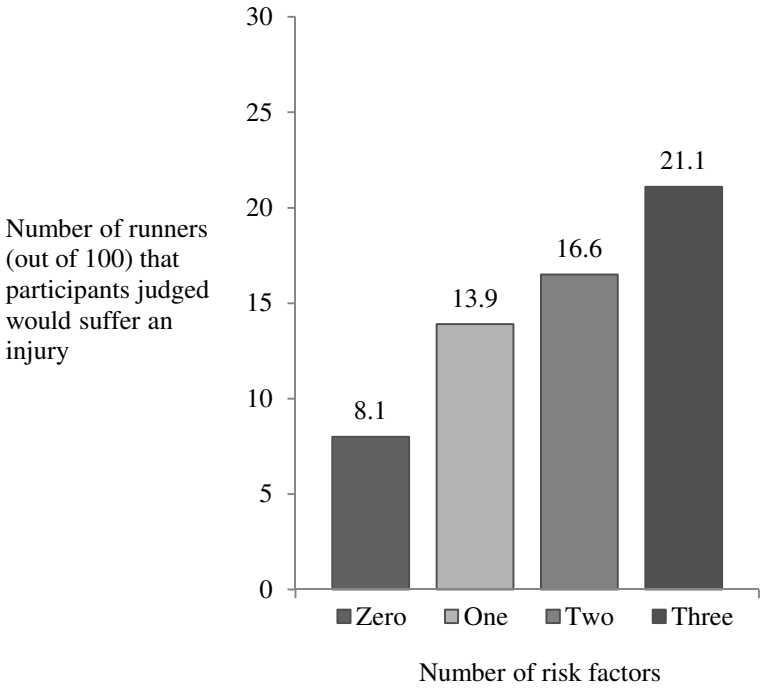

Figure 3. Study 3: Participants' (mean) judgments of the number of 100 men who would suffer a heart attack. Judgments are shown for each of the five risk factor conditions and for the two age conditions.